



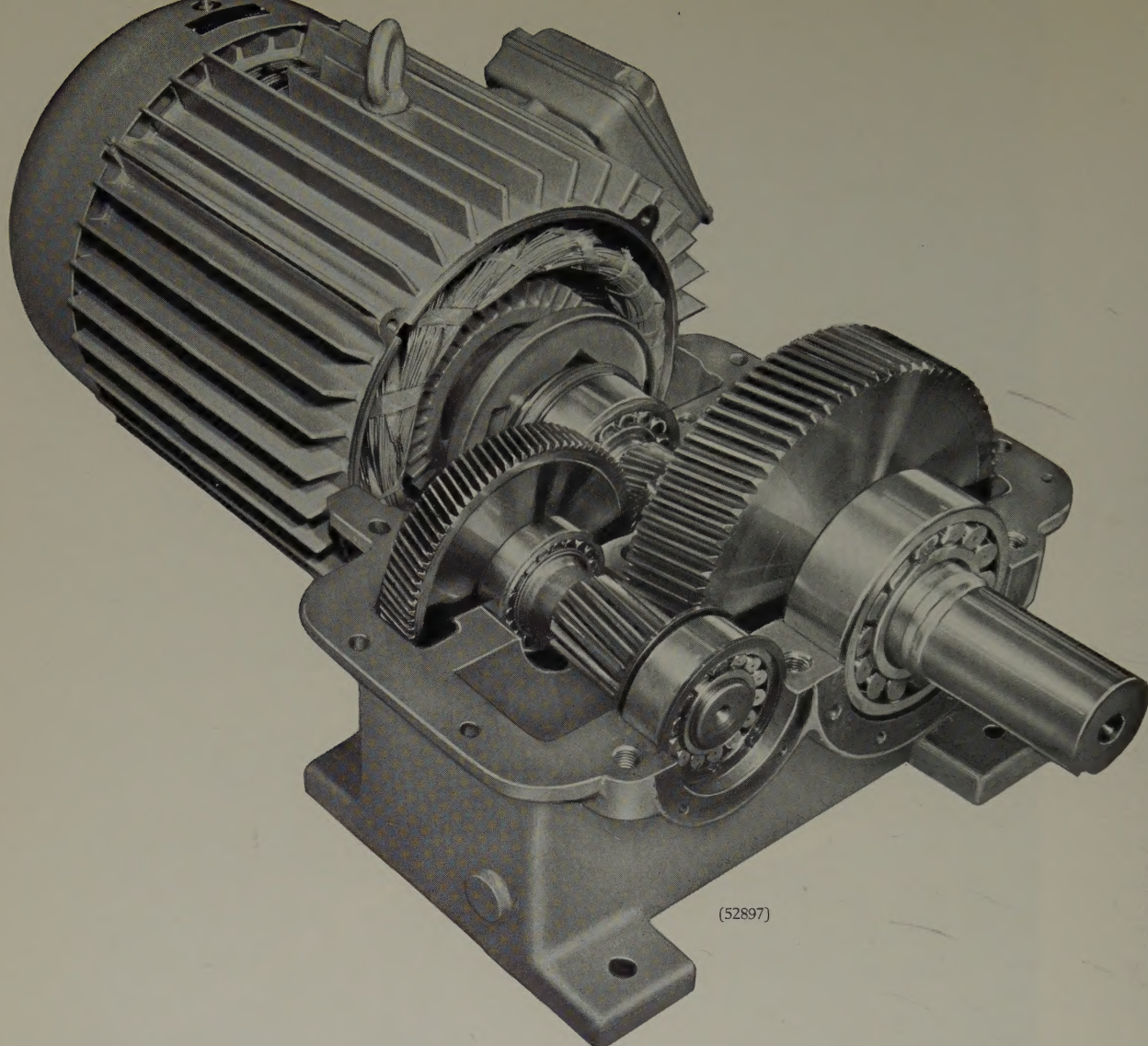
*Escalators at the Stockholm
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THE ESCALATORS ON THE STOCKHOLM UNDERGROUND RAILWAY

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The article describes the escalators which Asea have supplied to the Stockholm Underground Railway where they have proved particularly valuable because of their high capacity. The main features of the design are described and detailed accounts are given of the steps and chains, the tracks, balustrades, handrails, machinery and safety devices.

For the vertical transport of large numbers of persons, for example, at railway stations and underground railway stations, escalators have proved their worth because of their high capacity and their simplicity. Therefore, when the Stockholm Underground Railway was planned, escalators were naturally included.

In 1950, the first escalator on the Stockholm Underground Railway was taken into use, and, to-day, 41 Asea escalators are in use in the stations in the centre of Stockholm and the suburbs. During this period, considerable development has taken place and valuable experience has been gained. There has been close co-operation between AB Stockholms Spårvägar – the authority running the underground railway – and Asea on these matters and this has had a very advantageous effect upon development.

The building of the escalators quite naturally followed the various stages in the construction of the underground railway. The first escalator was installed in 1950 at the Medborgarplatsen station on the southern line. On the western line, which was opened to traffic in October 1952, 23 escalators were installed, and in the junction which was inaugurated in November 1957, there were 14, of which 9 were in the Stockholm central underground station alone. In the meantime, a further 3 escalators have been supplied to suburban stations and for the southern exit from the Hötorget station in the centre of Stockholm.

The three escalators at the western exit of the Fridhemsplan station have the greatest vertical lifting height, that is 18.2 m (60 ft) (Fig. 1). The steps of all the escalators are 1 m (3 ft 3 in.) wide and will take 2 persons per step. The angle of inclination is 30°. The speed of the lower escalators is a constant 0.65 m/s (2 ft/s) and on the higher ones it is variable up to 1 m/s (3 ft 3 in./s). The theoretical capacity is 190–300 persons per minute depending on the speed, the actual capacity is 130–140 persons per minute at 0.65 m/s (2 ft/s) without any noteworthy increase in capacity even if the speed of the escalator is increased, which is due to the fact that the flow of persons on to the escalators cannot be speeded up. For purposes of comparison, it may be mentioned that the exit barriers at the station with the highest number of passengers (Hötorget) are passed on a weekday morning at peak traffic by up to 350 persons per minute, of whom about 200 persons leave by the X exit at the corner of Kungsgatan and Sveavägen alone.

Fig. 1. The escalators at the Fridhemsplan station have the greatest lifting height, that is, 18.2 m (60 ft). (52367)





Fig. 2. An older design with oak ribs on the upper part of the steps. (52507)

THE MAIN FEATURES OF THE DESIGN

The steps on which the passengers travel are fitted with four supporting rollers which run on, and are guided by, a track and curve system. They are joined together to form an endless belt by means of two step chains, one on each side of the steps. At the two ends of the staircase, where the steps turn, the chains run over chain wheels which are located, at the top, on the main upper shaft which drives the chains, and at the bottom, on the lower main shaft which provides the tension for them. During their passage along the staircase, the passengers can support themselves on the handrail which runs synchronously with the escalator and is supported by the balustrade, which, at the same time forms the inside wall of the escalator. At the two ends of the balustrade, the handrails run over handrail wheels and down under the balus-

Fig. 3. Footplates of aluminium ensure reduced wear and greater safety when alighting. (52508)



trade where tensioning wheels are situated. The wheel at the upper balustrade end is connected to the drive system for the handrail.

There are comb plates at the entry and alighting end, the teeth of which run between the ribs of the steps and form an effective plough.

All the above-mentioned elements are supported by the framework of the escalator, which is a lattice-work structure resting on concrete plinths.

In front of the upper ends of the steel structure of the driving machinery of the escalator, consisting of a motor, wormgear and operating brake, stands on a concrete plinth. The machinery drives the upper main shaft of the escalator by means of chain gear. Alongside the driving machinery in the machine-room there is a control gear for the electrical equipment and for certain escalators, as well as a Leonard converter.

The escalators are operated by means of pushbutton mounted flush behind locked covers in the balustrade and in the machine-room, and by means of a photoelectric cell which gives an operating impulse when a ray of light in the escalator is interrupted.

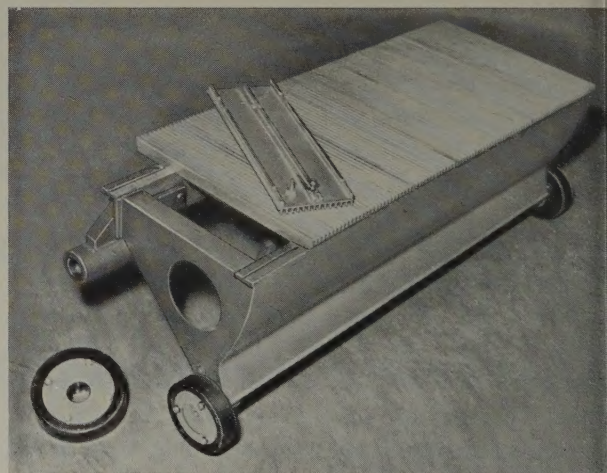


Fig. 4. The footplate is divided up into sections which are about 12 cm (5 in.) wide and can easily be changed in the event of damage. (52509)

STEPS AND CHAINS

In the first escalator at the Medborgarplatsen station the ribs on the upper side of the steps were made of oak (Fig. 2), which, at the time this escalator was supplied, was the material then in use. However, the next escalator supplied had aluminium footplates on the steps (Fig. 3). In addition to considerably lower maintenance costs because of reduced wear, this also implies considerably increased safety, since the risk of objects being caught between the ribs and the plough is almost completely eliminated. This made it possible to reduce the width



Fig. 5. The balustrades of the escalators were made, to begin with, of teak, which proved to stand up very well to wear and tear. (52505)

Fig. 6. Balustrades of laminated plastic glued to sheet steel are less dangerous in the event of fire and, at the same time, require no maintenance. (52504)



the step ribs from 20 mm (0.8 in.) to 3 mm (0.1 in.) and the distance between them from 20 mm (0.8 in.) to 6 mm (0.2 in.), and with a corresponding reduction in the width of the comb teeth, the gap between tooth and rib could be reduced to only 1.5 mm (0.059 in.) to 2 mm (0.079 in.). If any object (stones, nails, etc.) should fasten between the step ribs, the comb teeth are designed with a special weak spot and of such brittle material that the tooth breaks off. Thus, the ribs on the following steps are not damaged if the object fastens in the comb and the damage is limited to one broken tooth. Both the comb and the footplate (Fig. 4) are divided up into sections which are about 12 cm (5 in.) wide and which can easily be changed in the event of damage. The sections of the plate are extruded with a slot on the underside for the heads of the two fixing screws. The steps have welded frames of pressed and bent sheet steel.

The four supporting rollers of the steps are provided with ball bearings, and in the first escalators they were made of textile-reinforced bakelite in order to achieve the longest possible life. They have now gone about 100,000 km (62,000 miles) without any noteworthy wear. Unfortunately, escalators running on bakelite rollers are noisy in spite of the fact that the steps are provided with silencing material on the inside. Rollers made of ordinary synthetic rubber and natural rubber only have

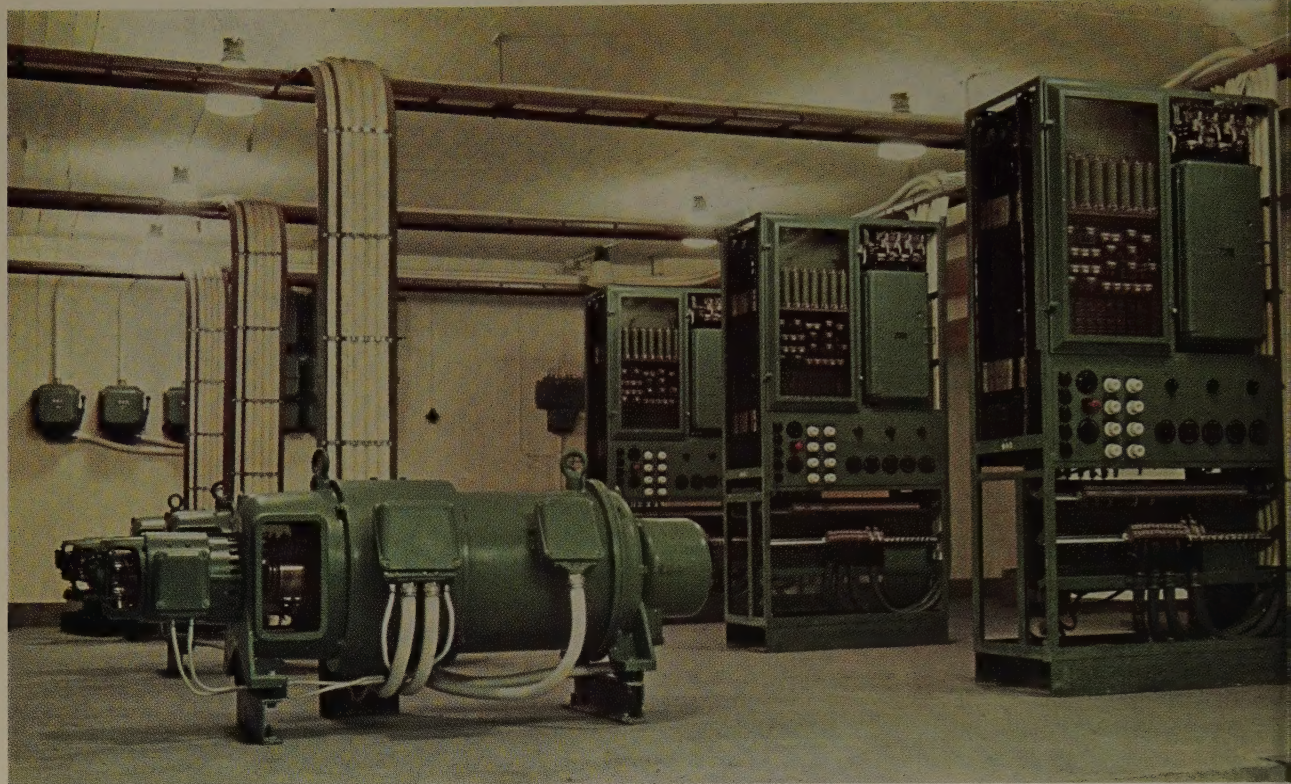


Fig. 7. The machine-room for the escalators at the Stockholm Central Underground Station. (F 387)

a satisfactory length of life if they are used for escalators with a low lifting height and little traffic, and therefore, the escalators supplied most recently have been provided with silicon-rubber rollers which both have a long life and run quietly.

The two step chains are linked with the steps by means of taps, which in the older escalators were fixed to the chain and carried in the steps in bearings, but in the later ones are fixed to the steps and carried in bearings on the chain. The latter system is the most advantageous since there is then no torque in the bearings and the taps can more easily be dismantled and assembled in the event of a change being necessary. The forward roller is carried on the tap between the chain and the step. In order to reduce the noise made when the chain runs on to the chain wheel, in the latest escalators, a shorter pitch has been selected for the step chain.

TRACKS AND CURVES

The tracks and curves for the steps are made of bright-drawn steel bars with diagonal joints. On the sloping straight parts opposite each other at intervals of 1 m (3 ft) there are two cast-iron brackets which support the tracks and protective rails for the rollers, the lowest aluminium profile in the balustrade and the fixing clamps for the stainless steel skirting. When the brackets are correctly adjusted, which is done with the aid of two

setting screws and with wires and pattens, the tracks etc. are mounted on the machined lugs on the brackets, thus taking up the correct position without requiring any further adjustment. At the transition between the sloping and the horizontal parts, the steps run on curves of rolled bright-drawn steel bars which are mounted on plates to form units ready for insertion in the step structure. They are joined at the one end to the straight sloping tracks and at the other end to the turning curve in which the steps are guided in on to the lower return track. At the upper end of the escalator the turning curves are fixed, but at the lower end they are allowed to move horizontally along the longitudinal axis of the escalators and, along with the lower main axle, they are carried in a spring-loaded tensioning frame for the step chains.

BALUSTRADES

Up to and including 1953, the balustrades of the escalators (Fig. 5) were clad with teak which proved to stand up very well to the considerable wear to which they were exposed. Demands for a design which was less liable to be exposed to the risk of fire and required, at the same time, no maintenance, led, however, to the present design (Fig. 6) with sides of laminated plastic glued on to sheet steel. The plates are mounted on a framework of anodised, extruded aluminium profiles. They are fixed in the profiles by means of internal screws or springs and the profiles are, in the turn, fixed to the brackets by means of internal screws

The joints between the plates are covered by aluminium trips which, on the top of the balustrade serve the purpose of preventing objects from slipping down. Next to the step there is a kicking plate of stainless steel which is fixed by means of internal clamps. Thus, the surface of the balustrade is free from screw heads and similar objects in which the clothes of the persons using the escalator could be caught, but all the component parts are, however, easy to change in the event of damage.

The wide range of colours available in laminated plastic have made it possible to fit the exterior of the escalators well in with the neighbouring parts of the underground stations.

HANDRAILS

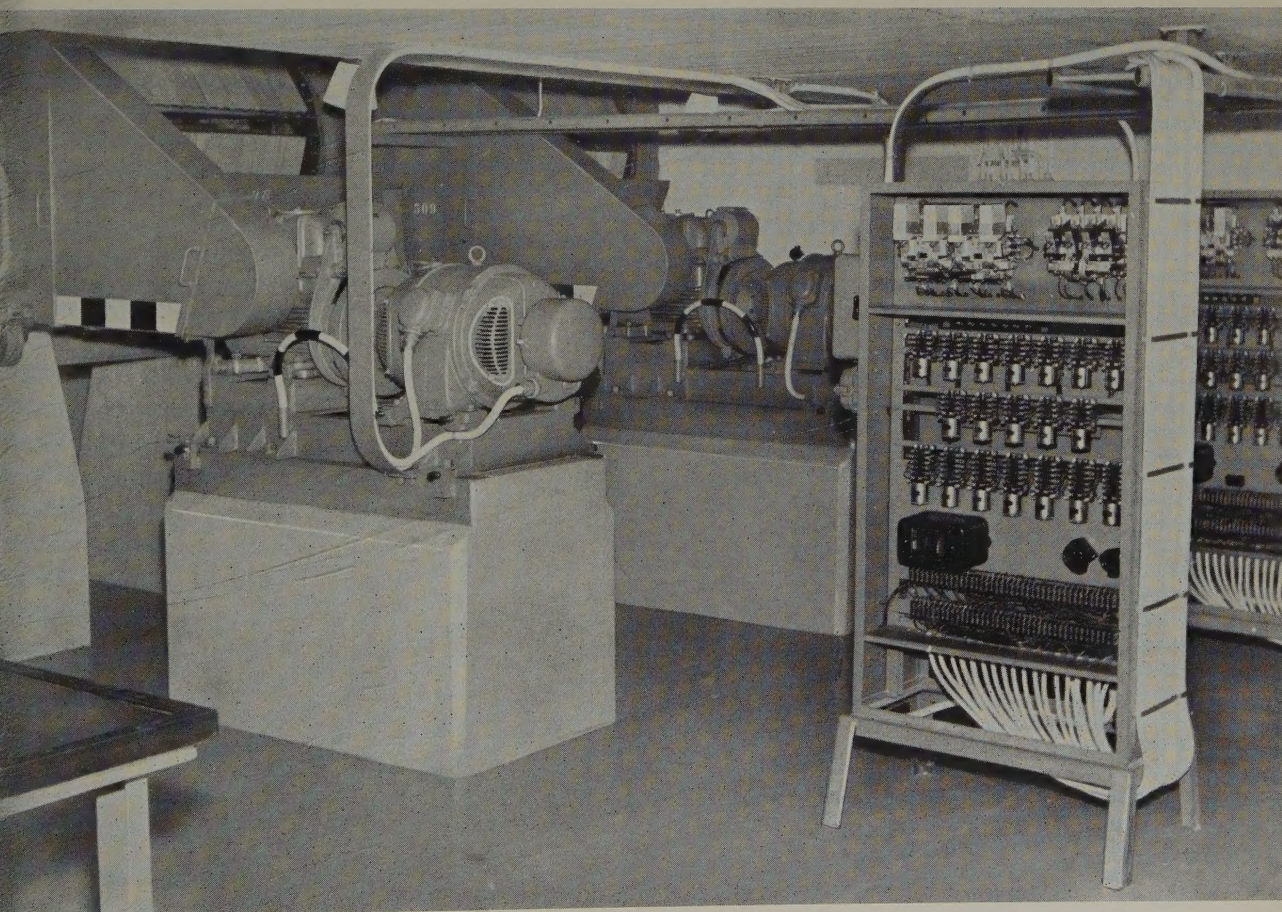
The moving handrail which is made of rubber on a canvas frame has, in the latest escalators, been provided with an insert of steel strip which has the great advantage that the length of the handrail is virtually constant irrespective of load and time of operation. It has been necessary, now and again, to shorten and rejoin the handrails without steel inserts, but this is no longer necessary with the new steel-reinforced type. Further, the construction of this type of handrail is more stable and it is also firmer to hold.

The driving and tensioning devices for the handrail are placed under the balustrade at the upper end of the escalator and consist of a tensioning wheel and two driving wheels over which the handrail runs in a loop in order to make the angle of wrap as large as possible. The driving wheels are driven from the upper main shaft by means of chain gear. On the upper side, the handrail is guided by a bar made of steel or beech and, underneath, it is supported on rollers carried in ball bearings.

MACHINERY

When the escalators at the Fridhemsplan station were planned in 1947, it was laid down that they should have four speeds, that is, 0.5, 0.75 and 1.0 m/s (1 ft 8 in., 2 ft 6 in. and 3 ft 3 in. per second) normal speeds and a crawling speed for maintenance work. The machinery was designed with three-phase slip-ring induction motors for each normal speed and a three-phase crawling-speed set with a wormgear, and all the units were placed in a row on a girder framework. For reasons of safety, the speed of 1 m/s (3 ft 3 in./s) was only intended for escalators running upwards. To begin with, the escalators

Fig. 8. The machinery with motor, wormgear and operating brake is placed on a girder frame which can be moved in the longitudinal direction of the escalator. (52506)



were run at a speed of only 0.5 m/s (1 ft 8 in./s), but gradually, as the public got used to these staircases, the speed was increased to 0.75 m/s (2 ft 6 in./s), at which speed the escalators are now normally run.

The high escalators at the Stockholm Central Underground Station (see the illustration on the cover) which were most recently supplied, are designed for continuous speed regulation by means of Leonard control (Fig. 7) and transducer regulators and for a maximum speed of 1 m/s (3 ft 3 in./s). This means that the speed can readily be adapted to traffic conditions existing at any time. Crawling speed for maintenance purposes is arranged without any special devices by means of the ordinary speed-regulation equipment.

All the machinery (Fig. 8) with motor, wormgear and operating brake is placed on a girder frame which can be moved in the longitudinal direction of the escalator so that the tension on the driving chain between the wormgear and the upper shaft can easily be regulated.

SAFETY DEVICES

In addition to the operating brake on the machinery, the escalators have a safety brake in the form of a band brake which works on a brake wheel directly on the upper main shaft. This brake is operated partly by means of a speed guard which functions when the speed of the escalator becomes excessive, and partly by means of a weight-actuated arm in the case of a break in the driving chain. The step-chain wheels at the lower end of the escalator operate a sensitive contact device which breaks the operating current so that the escalator stops if one

of the chains should be abnormally stretched or broken. In the case of the handrail, there are in the same way contacts which stop the escalator in the event of a break in, or stretching of, this handrail. In addition to the above-mentioned speed guard which actuates the safety brake, there is an electric speed guard which breaks the operating current in the event of excessive speed, before the mechanical guard comes into action.

At the top of the balustrade there is emergency stopping equipment which is readily accessible to the passenger. This has a thin paper window which can be pushed in the case of danger, whereupon a stopping contact is actuated. In addition, there are stop buttons at the main barriers for operation by the staff. If an escalator stops because of a fault, emergency stopping, etc., the staff are warned by means of a buzzer and can then, with the aid of an indicating panel at the main barrier, find out the reason for the stoppage and what measures should be taken.

MAINTENANCE

When the escalators were designed, particular attention was paid to the fact that it should be possible to lubricate, clean and otherwise maintain the escalators while they were in use and in a way which would not interfere with the public. Practically all the necessary inspections can be carried out from the maintenance spaces around the escalators and in the machine-room. All the moving parts are accessible from these spaces. Steps and rollers can, if necessary, easily be changed from these points and the most inaccessible lubricating points are provided with lubricating ducts.

CONTACT RESISTANCE MEASUREMENTS WITH A.C.

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Up to now the measurement of contact resistance by means of a.c. has proved to be difficult to accomplish, and generally such measurements have had to be performed with d.c., despite the fact that the conditions with d.c. differ essentially from those with a.c. Recent developments in the field of Hall generators have made it possible to design a simple and practical measuring equipment for a.c. The article describes an equipment of this type developed at the Asea High-power Laboratory, Ludvika.

GENERAL PRINCIPLES OF THE HALL GENERATOR

The Hall generator (the operation of which is based on the Hall effect) comprises, in principle, a strip of semi-conducting material, usually indium antimonide or indium arsenide [1, 2]. If such a disc is placed in a magnetic field with the flux density B (Fig. 1) and if a control current I_c flows through it, a voltage U_H (the Hall voltage) develops perpendicular to the direction of the current flow. This voltage is proportional to the product of the flux density and the control current ($U_H \sim I_c B$).

Hall generators of indium arsenide are scarcely influenced by temperature variations and are not affected by any inertia within a large frequency range, which means that they possess a high degree of accuracy. Owing to these properties, the Hall generator is finding an ever wider application within the field of electric measurements [3, 4, 5].

MEASUREMENT PRINCIPLES

When measuring contact resistance with a.c., it is impossible to prevent voltage from being induced in the loop of the measuring circuit (Fig. 2). If the contact

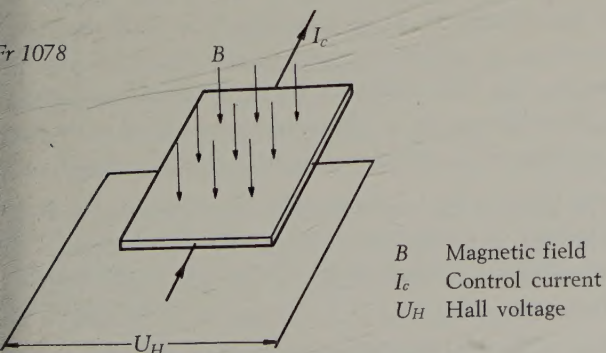
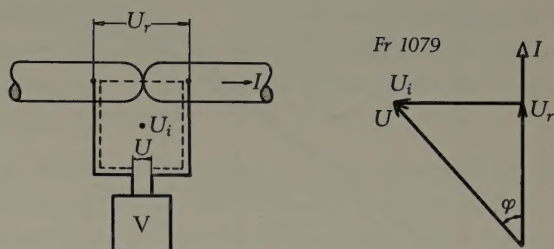


Fig. 1. Hall generator.



I	Load current	U	Resultant voltage
U_r	Contact voltage drop	V	Voltmeter
U_i	Induced voltage		

Fig. 2. The influence of induced voltage on a.c. measurements.

resistance is relatively low, the induced voltage U_i is of the same order as the resistive voltage drop U_r across the contacts, and, as can be seen from the vector diagram, the resultant voltage U is completely distorted.

In order to avoid this error, a measuring principle based on the direct measurement of the active power should be adopted. The Hall voltage in a Hall generator maintains its polarity even if both the field and the control current change polarity. Consequently, if a Hall generator is fed with an alternating current I and an alternating voltage U having a phase displacement of φ , the output voltage will contain a d.c. component proportional to the active power. By measuring the output voltage with a galvanometer, it is possible then to determine directly the contact losses, and thereby the contact resistance. An elementary diagram of the measuring equipment is shown in Fig. 3.

The Hall generator is placed in the air-gap of an iron core Fe , which surrounds the current-carrying conductor S , and its control circuit is connected to the two con-

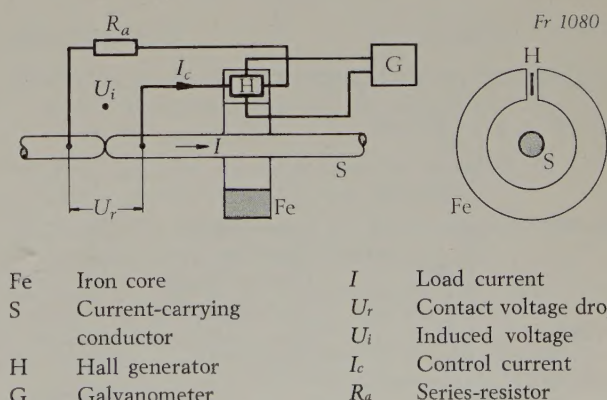


Fig. 3. Elementary diagram for measuring contact resistance utilising a Hall generator.

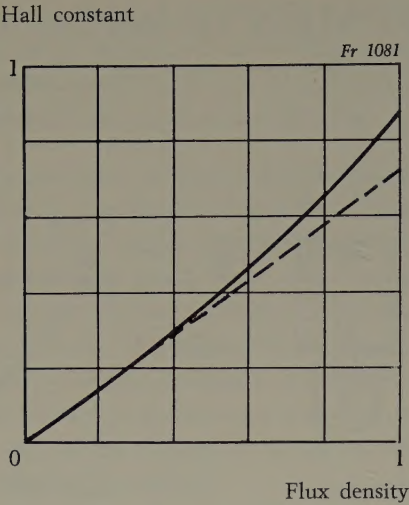


Fig. 4. Relationship between the Hall constant and the flux density.

tact members between which the losses are to be measured. The Hall voltage is measured with a galvanometer G.

The flux density in the iron core is proportional to the current I flowing through the conductor S, and the control current I_c is proportional to a voltage U , which has two components (see Fig. 2), the contact voltage drop U_r (which is in phase with I) and the voltage U_i induced in the loop of the measuring circuit (U_i being perpendicular to I). The voltage U_i also includes the inductive voltage drop in the conductor between the two points of measurement.

The Hall voltage will thus be

$$U_H = c I \sin \omega t \cdot U \sin (\omega t - \varphi) \tag{1}$$

where c is a constant and φ is the phase displacement between U and I .

When the Hall voltage is measured with a galvanometer (G), the instrument deflection will be proportional to the d.c. component of the Hall voltage.

The d.c. component is

$$U_{Hd} = c_1 I U \cos \varphi = c_1 I U_r \tag{2}$$

where c_1 is a constant.

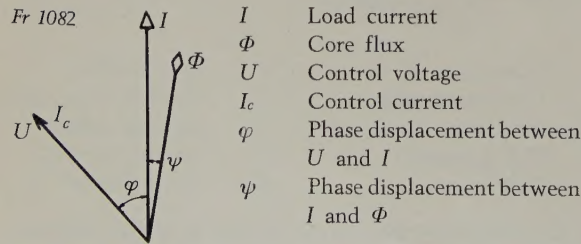


Fig. 5. Influence of the core losses.

The inductive component U_i (and also, of course, the active component U_r) will only occasion a vibration around the mean value of the instrument deflection. The amplitude of the vibration is dependent on the moment of inertia of the instrument and hardly influences the accuracy of reading when standard d.c. instruments are employed.

ACCURACY OF MEASUREMENT

The resistance, on the control side of the Hall generator increases approximately to double the value when the flux density rises from 0 to 1 Wb/m² [6]. This resistance determines the control current of the Hall generator and since the current decreases with increasing flux density (assuming constant control voltage), the Hall voltage will also decrease. This reduction in the Hall voltage cannot, however, attain its full effect, since the Hall constant (U_H/I_c) in its turn increases with the flux density (Fig. 4) and thus partly compensates for the change in resistance on the control side.

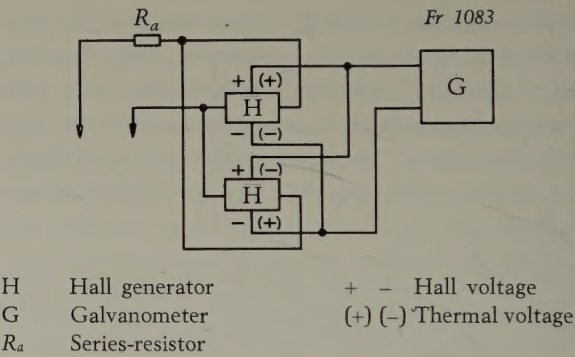


Fig. 6. Elimination of the thermal voltage.

An improved linearity is obtained if a resistor R_a is connected in series with the control circuit of the Hall generator (Fig. 3). By selecting a resistance of approximately 5 times that of the Hall generator on the control side, without magnetic field, a linear relationship, with an accuracy of ± 1 per cent, will be obtained between the contact voltage U_r and the Hall voltage U_H (with I being constant).

If this accuracy is to be maintained, the Hall generator must not be subjected to any pronounced load. For this reason, the Hall voltage must be measured with a d.c. instrument having a relatively high internal resistance, for example, a galvanometer with optical pointer.

The losses of the iron core also cause a measuring error. The flux Φ of the iron core and the load current I are in fact displaced by the angle ψ (the loss angle) (Fig. 5). Since the product of I_c ($\sim U$) and Φ is formed in the Hall generator, the d.c. component of the Hall voltage will be



Fig. 7. Device for measuring contact resistance (max. 500 At). (Z 11002)

$$U_{Ha} = c_2 \Phi U \cos(\varphi + \psi) \quad (3)$$

where c_2 is a constant.

The angle ψ is given by the expression

$$\tan \psi = c_3 d / nI \quad (4)$$

where c_3 is a constant.

With the flux density = 1 Wb/m², the core losses = 0.5 W/kg, the frequency = 50 c/s, the mean diameter of the core $d=0.1$ m, the number of winding turns on the core $n=1$ and the load current $I=500$ A, we have

$$\tan \psi \approx 10^{-2}$$

which causes a measuring error of -1 per cent, when

$$\tan \varphi = U_i / U_r \approx 1$$

Since the resistive and inductive voltage components U_r and U_i , at constant frequency, are both proportional to the current I , the phase displacement φ remains constant when the current varies, and the measuring accuracy increases if the induced voltage component is maintained within reasonable limits by utilising twisted leads. The accuracy is still further increased if the core is designed with a larger air-gap and consequently more turns (cf. equation 4). In practice, it has proved possible to measure at 50 c/s the contact losses at resistance values down to 10^{-4} to 10^{-5} ohms without adopting any special measures.

A measuring error may also occur due to the effect of the thermal voltage of the Hall generator. Owing to the

contact between dissimilar metals (terminals and basic material) in the Hall generator, this will yield, in addition to its control current, a voltage when there is a temperature difference of a few degrees between the two terminals. Since the Hall generator is placed in the air-gap of the core, a temperature difference of a few degrees can easily prevail, which will result in thermal voltage due to the heat radiation from the current-carrying conductor.

This error can be almost entirely eliminated by connecting in parallel two Hall generators in such a way that the thermal voltages will be short-circuited, whereas the Hall voltages act in parallel (cf. Fig. 6). It is nevertheless desirable to protect the Hall generator against excessive heat radiation, since the Hall constant changes by approximately 0.2 per cent for a change in temperature of 10°C.

Considering all the external and internal factors, a measuring equipment based on the above principles will have an accuracy of approximately ± 1.5 per cent.

CALIBRATION

Calibration is most simply carried out by measuring the losses in a known resistor r , free from eddy currents, at a variable load current I . By selecting a value of $n=1$ (the number of winding turns on the core), the galvanometer deflection will be

$$\alpha = cI^2r \quad (5)$$

where $c = \alpha / I^2r$ is a constant, denoting the sensitivity of the measuring arrangement, and which can be set to a suitable value with the aid of the series-resistor R_a . This sensitivity can be improved during the measurements by increasing the number of winding turns around the core.

The sensitivity is generally given in mV/W. Fig. 7 shows a measuring device for max. 500 At with a sensitivity of 0.1 n mV/W.

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40 MVA SYNCHRONOUS CONDENSER IN CANADA

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Brief description of a 40 MVA synchronous condenser and ancillary equipment supplied by Asea for the Quebec Terminal Station of the Shawinigan Water and Power Company at Limoilou, Quebec, Canada.

A recent issue of the Asea Journal [33(1960):3, pp. 40-42] described a 36 MVA generator ordered by Shawinigan Engineering as part of the planned enlargement of the generating capacity of the Shawinigan Water and Power Company. A map of the region involved was included in this article.

Owing to the increased load requirements, which were to be met by means of this enlargement programme the 66 kV transmission line to Quebec became severely strained, and thus it was found necessary to improve the load power factor by installing yet another synchronous condenser. This unit was installed in the Transformer Terminal Station at Limoilou, Quebec, and Asea received the order for the synchronous condenser and

ancillary equipment. By improving the load power factor the voltage regulation was also enhanced.

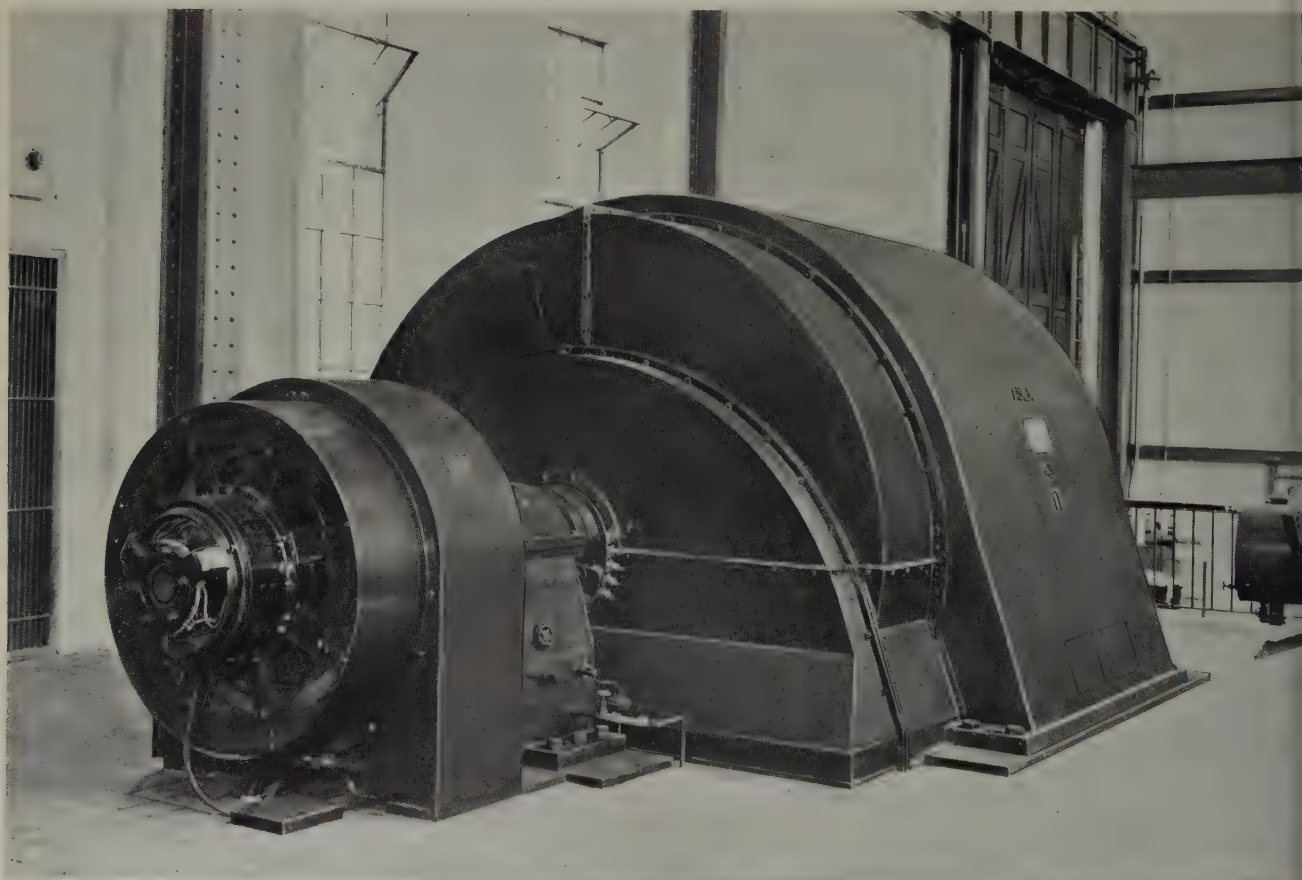
THE SYNCHRONOUS CONDENSER

The machine, which is of indoor type, is provided with main and pilot exciters coupled to an extension of the main shaft. It is of self-ventilated design with separate inlet and outlet ducts for the cooling air. The stator casings, base and bearing pedestals are of welded construction. The machine is equipped with CO₂ fire-extinguishing equipment and the requisite closing shutter are fitted in the cooling air-ducts.

Main data:

Output	40 MVA
Speed	900 r.p.m.
Frequency	60 c/s
Voltage	13.8 kV
Excitation	220 V, 450 A
Output when under-excited	20 MVA

Fig. 1. Synchronous condenser for 40 MVA in the Terminal Station at Limoilou, Quebec, Canada. (49325)



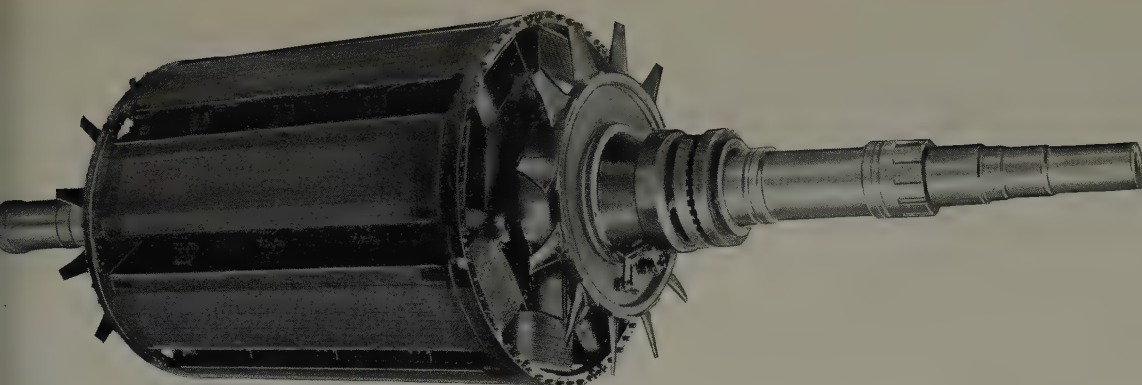


Fig. 2. The rotor is designed with a body and shaft forged in one piece with dovetailed laminated poles. (44371)

The stator winding is designed as a diamond-coil winding with two coil sides per slot, where each coil side comprises one conductor divided into several rectangular strands insulated from one another. The coil insulation, which constitutes at the same time the conductor insulation, is of mica tape with asphalt varnish as bonding agent. The mica tape has been wound continuously in a large number of layers around both the slot part of the coil and the coil ends, after which the winding assembly has been impregnated under pressure in vacuum with an asphalt compound. This process has been repeated several times during the insulation work. The coils are designed with corona protection and the coil ends are braced with insulated rings of non-magnetic material supported against the stator.

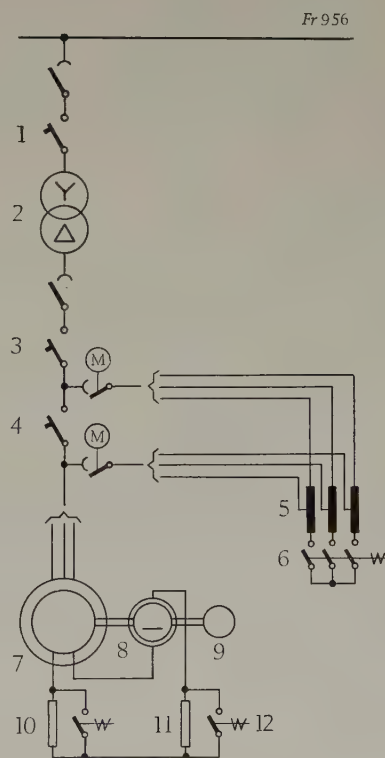
The rotor has a solid body and shaft forged in one piece with dovetailed laminated poles (see Fig. 2). The field winding comprises copper bars with insulation of varnished paper between turns and insulation of phenolic laminate facing the core. The rotor has a damping winding with bars of tinned bronze and copper rings. The fan blades on the rotor are of impeller type.

The bearings are journal bearings of self-lubricating type, the circulation of the oil being achieved with the aid of lubrication rings. The hot bearing oil is led off through ducts in the bearing brasses and flows to the oil well in the bearing frame, which has built-in oil coolers. Each bearing is equipped with a motor-driven oil pump for supplying lubricating oil under pressure when starting the set. The pumps are stopped automatically when the set has attained half its rated speed.

The main exciter, which is coupled direct to the main shaft, has a laminated stator and is designed with a hunt winding and a cumulative series winding. The pilot exciter, which is built together with the main exciter, supplies current to the driving motor of the impulse-exciter set during automatic regulation and to

the field winding of the main exciter during manual regulation.

The synchronous condenser is started with reduced voltage from a starting transformer, during which the machine current amounts to approximately the full-load value, whereas the line current is about 23 per cent of this. The starting time is approximately 1.5 minutes from standstill to full speed. The starting equipment is designed for both manual and fully automatic starting.



- | | |
|--|-----------------------------|
| 1. 66 kV main circuit-breaker | 6. Starting circuit-breaker |
| 2. 40 MVA transformer | 7. Synchronous condenser |
| 3. 13.8 kV circuit-breaker for the set | 8. Exciter |
| 4. Service circuit-breaker | 9. Pilot exciter |
| 5. Starting transformer | 10. Starting resistor |
| | 11. Discharge resistor |
| | 12. Field circuit-breaker |

Fig. 3. Circuit diagram for the synchronous condenser.



Fig. 4. Switchgear cubicles for circuit-breakers, voltage transformers, isolating switch of the braking resistor, etc. (44256)

Braking can be carried out electrically after the machine has been isolated from the network and its field suppressed. For this purpose, a braking resistor is connected to the stator terminals, after which the machine is excited again.

THE SWITCHGEAR

The Asea delivery included the complete switchgear and control equipment for the set in accordance with the diagram shown in Fig. 3, comprising metal-clad cubicles for the various circuit-breakers with instrument transformers, etc., and, in addition, instrument and relay panels for the starting and supervision of the set.

Four cubicles, built together (see Fig. 4), were required for the three circuit-breakers with their accessories, the voltage transformers and the isolating switch of the braking resistor. In addition, the equipment included a separate cubicle for the field circuit-breaker as well as another one for the voltage regulator of transducer type, and a self-contained impulse-exciter set.

The voltage regulator is fitted with an adjustable current limiter, which prevents the set from becoming under-excited to such a degree that it may fall out of synchronism.

The two circuit-breakers, which are normally connected up between the 66 kV step-up transformer and the set, have a rupturing capacity of 450 MVA at 13.8 kV. The circuit-breaker in the neutral point of the starting transformer is intended to interrupt 14.5 kA at 4.5 kV and,

furthermore, withstands the starting current of the machine amounting to max. 1.8 kA for 2 minutes. The two isolating switches of the starting transformer are motor-operated.



Fig. 5. Control board with mimic busbar. (44257)

THE PROTECTIVE EQUIPMENT

The protective equipment comprises:

1. Open-phase protection for the winding conductors
2. Differential protection for the set
3. Earth-fault protection for the stator
4. Thermal protection in the windings and bearings
5. Earth-fault protection for the field winding

In addition, the entire 66/13.8 kV equipment has the following protective gear:

1. Gas relay in the step-up transformer
2. Differential protection including the set and transformers
3. Over-voltage protection
4. Under-frequency protection
5. Thermal protection in the starting transformer
6. Over-current protection

Only audible signals are obtained from the thermal protections in the stator winding, the earth-fault protection in the field winding, the gas relay in the main trans-

former and the thermal protection in the starting transformer. In the case of the other protections, all the circuit-breakers of the set are tripped, the set is demagnetised, and an audible signal is given.

Should an excessive temperature develop in the bearings, the set will be automatically braked to a standstill.

The auxiliary direct voltage of 125 V is distributed from the station battery to three individual circuits, namely, the control circuit, the protective circuit and the indicating circuit. In addition, a voltage of 27 V, supplied from a rectifier, is utilised for the temperature-checking circuits.

Each circuit has its own miniature circuit-breaker, and under-voltage relays are utilised for indicating their tripping or a voltage failure due to any other reason.

Two panels in the control board (Fig. 5) are occupied by the metering instruments and protective relays. A separate cubicle has been set up in the machine room for the automatic starting equipment.

A NEW SERIES OF GEARED MOTORS

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Asea Reg. 2381

The new Asea geared motor with horizontal reduction gearing is compared with the older type with vertical reduction gearing. The new series is described with particular reference to design, lubrication, dimensions, bearings and appearance.

A new gear has been designed in conjunction with the new motor series type MBRC [see Asea Journal 29 (1956):3, pp. 23-29] to take the place of the previous Asea geared motors of types MK-UBA and MK-UBB [see Asea Journal 10(1933):7, pp. 90-94]. For the moment, the series is confined to double-stage gears with a maximum ratio of 1-40. This gives with a six-pole motor an approximate lowest speed of 24 r/m. If necessary, even lower speeds can be obtained by using a slow-running motor. The power and ratio of the new series can be seen from Table 1.

Since the new geared motors have been designed in accordance with partially new principles, it may be of interest to make certain comparisons with the older types. In the smaller of these (type MK-UBA) the gear stages are vertical (see Fig. 1) while, in the new geared motor they are horizontal. The cover of the gear is split at the level of the reduction stage, which means that all the bearings and shafts are revealed if the upper half of the cover is removed. This can clearly be seen from Fig. 2 which shows a geared motor rated at 30 kW with the ratio 1465/92 (type MBRC 22-UAAB 255).

In the older type of geared motor (MK-UBA), with the stages of the gearing placed vertically, the oil-level in the gear was relatively low in relation both to the input and output shafts. This meant in its turn that, in the case of these gears, it was possible to use open seals

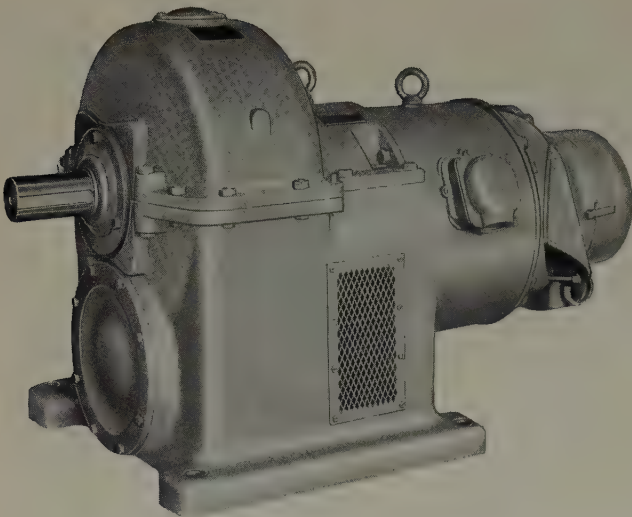


Fig. 1. Older geared motor (type MK-UBA) with vertical reduction gearing. (40648)

since, because of the low oil-level, it was easy to drain the bearing seats, but that also meant that the gears could not be mounted in different positions without changing the design.

In the new geared motor where the reduction stages are horizontal, the oil-level relative to the input and output shafts is higher, and this means that it is more difficult to use open seals. Therefore, in this case, elastic gaskets have been adopted. At the same time, the advantage has been gained that the gears can, without great difficulty, be mounted in various positions, for example, on a ceiling or on walls with the outgoing shaft end horizontal, or vertically downwards.

As previously, the gears are of oil-lubricated design which, from the point of view of operation and maintenance, is the best. The joints in the gear casing are sealed with a new sealing compound made by Asea (ASEAL, type number 4803), which has proved to be fully comparable with the best sealing compounds on the market. The compound has very great adhesion and never entirely sets. By using elastic gaskets and the special sealing compound, the tightness of the gearbox is perfect.

The gears can also be grease lubricated. In certain cases this is necessary, for example, in the case of underslung motors when there is a risk of fire if oil-filled gears are used. In other cases, the customers may, for some reason or other, particularly wish to have grease-lubricated gears. The reduction in the life of the gearing which is then experienced is not particularly significant in the case of low speeds or intermittent service. However, as far as possible, grease lubrication should be avoided since it can never give perfect lubrication.

In Fig. 3, a drawing of a new geared motor has been superimposed on a drawing of an older one, from which

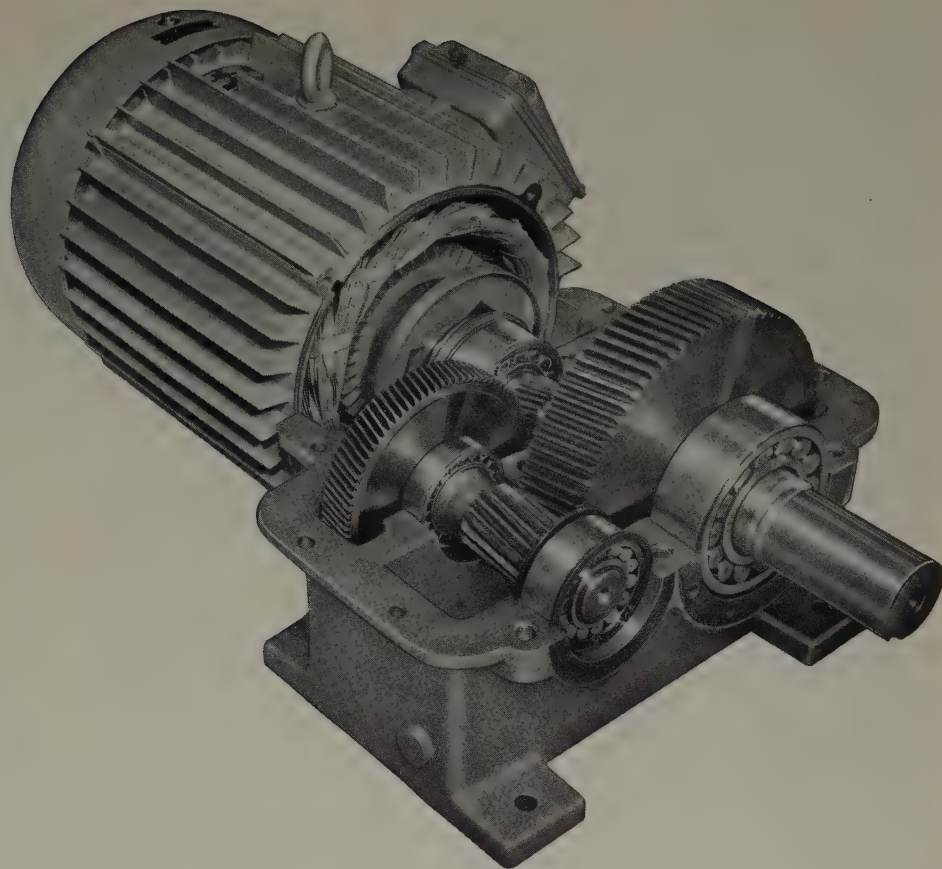
Table 1. Power and ratio of the units in the new geared motor series.

Type		Number of poles	Rated output		Standard speed on the free shaft of the gear
			kW	h.p.	
MBRC	UAAB				r/m
15	248	6	5.5	7.5	154, 121, 96, 75, 60
15	253	6	5.5	7.5	47, 38, 30, 24
15	248	4	7.5	10	233, 184, 146, 114, 90
15	253	4	7.5	10	71, 58, 46, 37
17	249	6	9	12	151, 122, 95, 76, 59
17	256	6	9	12	48, 38, 30, 24
17	249	4	11	15	229, 184, 143, 115, 90
18	250	6	11	15	76, 59
17	256	4	11	15	46, 36
18	257	6	11	15	31, 24
19	251	6	13	18	154, 124, 96, 77, 60
19	258	6	13	18	49, 39, 31, 24
18	249	4	15	20	229, 184, 143
18	250	4	15	20	115, 90
20	252	6	15	20	78, 60
18	257	4	15	20	46, 37
20	259	6	15	20	30, 24
19	251	4	18	25	233, 187, 144, 115, 90
21	254	6	18	25	78, 61
19	258	4	18	25	46, 37
21	260	6	18	25	31, 25
20	251	4	22	30	233, 187, 145
20	252	4	22	30	118, 91
22	255	6	22	30	78, 61
20	259	4	22	30	46, 36
22	261	6	22	30	30, 24
21	254	4	26	35	232, 188, 147, 117, 92
21	260	4	26	35	73, 59, 47, 37
22	254	4	30	40	232, 188, 147
22	255	4	30	40	117, 92
22	260	4	30	40	73, 59
22	261	4	30	40	46, 37

it will be seen that the difference in dimensions is considerable. Because of the method of construction adopted, with the reduction stage lying horizontal, the output shaft will be displaced somewhat to the side in relation to the centre line between the feet of the geared motor. Further, the height of the gear will be considerably lower than if the reduction stage had been vertical, and this means that it is particularly suitable for use in locations where the available height is limited.

The outgoing shaft-end of the geared motor has been designed for use with gear-wheels, belt pulleys or chain wheels. For example, the permitted radial force at the middle of the outgoing shaft-end is, in the geared motor shown in Fig. 2, 2,300 kg. By far the greater number of customers ordered this design previously and it has therefore not been thought justified to make an alternative design for direct running. This also means that

Fig. 2. The new geared motor (type MBRC-UAAB) with horizontal reduction gearing. The joint in the housing of the gearing coincides with the reduction cage which means that all the bearings and shafts are revealed if the upper half of the housing is lifted off. (Fr 52897)



The geared motor can very simply be moved and used for various types of drive.

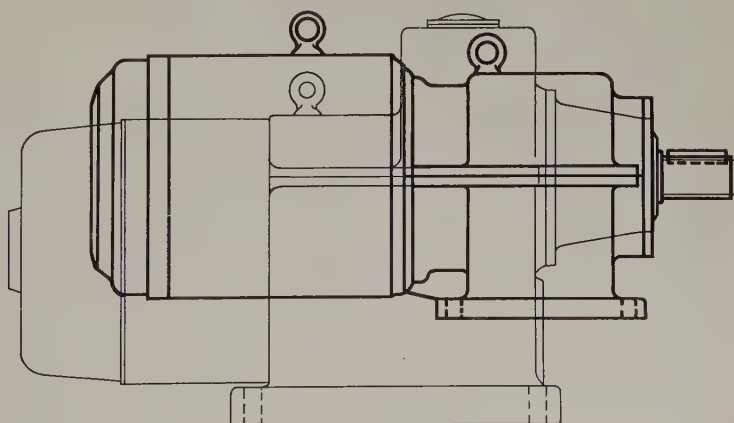
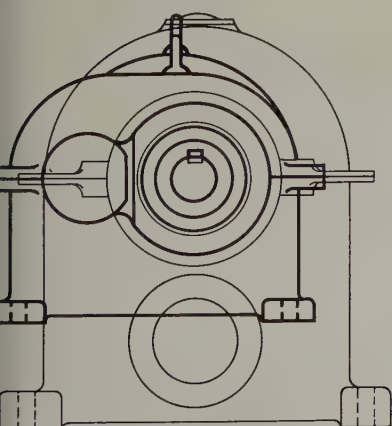
The gear has SKF roller bearings throughout. They are built for a life of at least 40,000 running hours. All the roller bearings, with the exception of the forward bearing of the motor, are oil lubricated.

The material in the gear-wheels is high-alloy, case-hardened or tempered steel, depending on the load on the gear-wheel in question. By using case-hardened steel, particularly for the pinion, it has been possible to reduce the dimensions of gear-wheels considerably as compared with previous designs.

The gear profile has been designed in accordance with the latest experience with regard to the maximum utilisation of material both with reference to surface pressure and bending stresses. Intensive research has been carried on in this field, thus enabling the achievement of optimum strength, amongst other things by the profile displacement of the gear teeth.

Because of the great transmission capacity of the gear-wheels, harder shrink fits have to be adopted for fixing

Fig. 3. Sketches of an older geared motor type UBA 15 (thin lines) and a new motor type UAAB 248 (thick lines) with the latter superimposed on the former. As will be seen, the differences in dimensions are considerable. (Fr 1077)



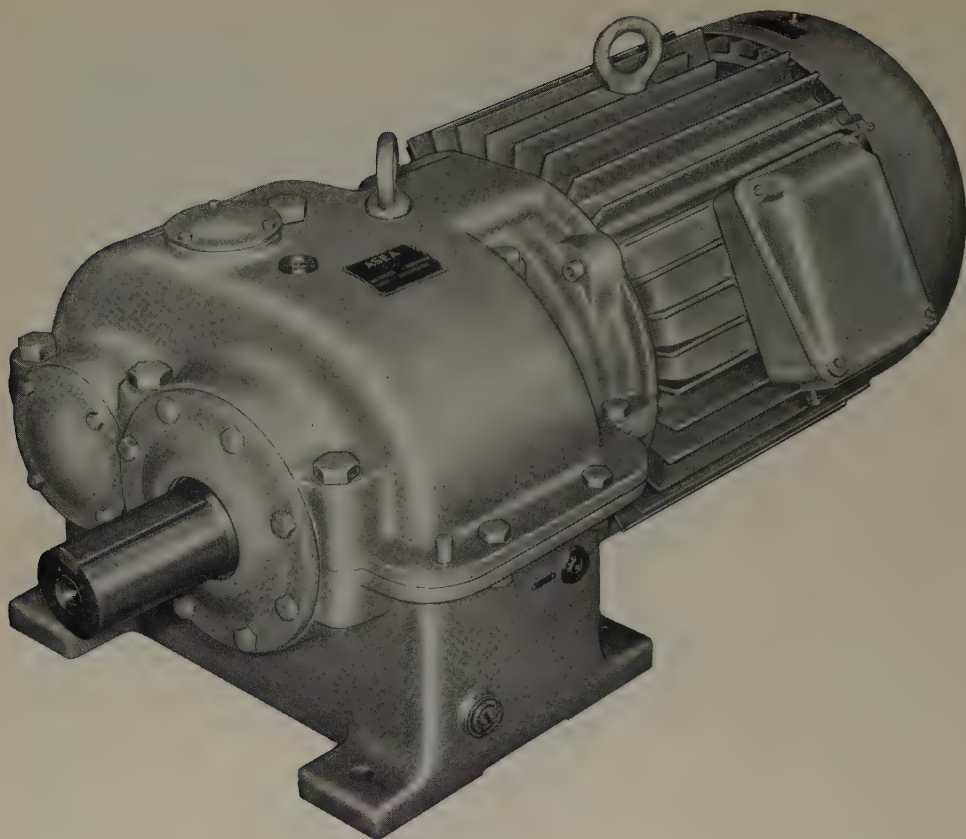


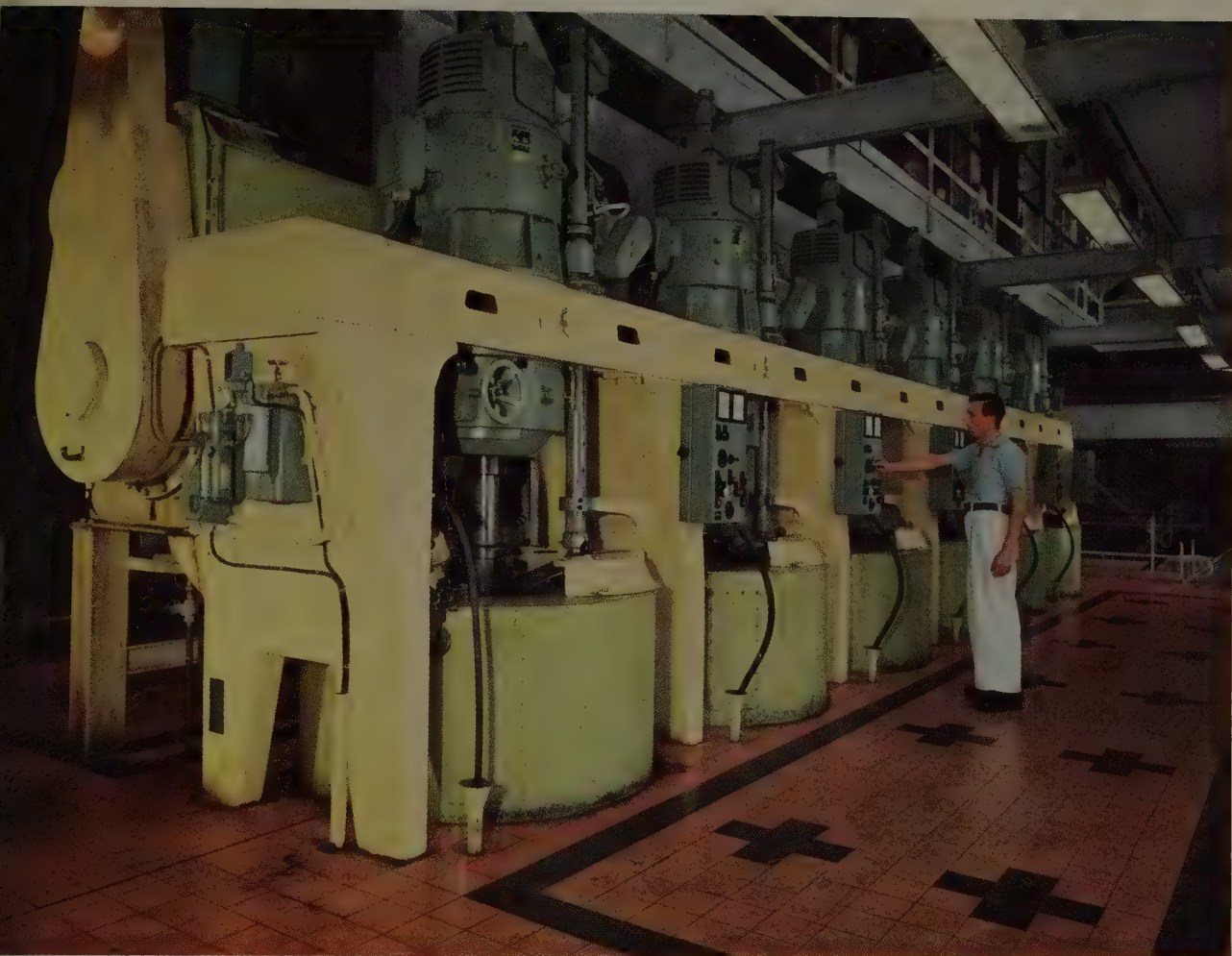
Fig. 4. A complete 30 kW geared motor with the ratio 1465/92 (type MBRC 2 UAAB 255). Its low height means that the motor is particularly suitable for use in places where the available height is limited. (52898)

these, and this gives reliable joints even in the case of very jerky and heavy loads. Experience has shown, however, that, in spite of the extremely hard shrink fits, it is possible to pull off the gear-wheels from their seatings if it is necessary to change the ratio. There is no risk of spoiling the fitting surface if the one material is case-hardened steel.

As is the case for the other Asea gear designs, the gear housings are machined in highly accurate special machines. The gear-wheels are cut and machine shaved or ground, which provides a product which is first-

class in every respect. The fine-machining operation gives, in addition to the correct involute profile, a certain slightly bowed shape along the flanks of the teeth – crowning – which guarantees that the outer edges of the gear teeth will not be overloaded.

It may generally be said that the new series of geared motors has been designed in accordance with the latest experience in the field of gears without, for that reason, having to abandon any of the customers' wishes as far as practical design with reference to assembly and maintenance are concerned.



(F 451)

COMPLETELY AUTOMATIC SUGAR CENTRIFUGALS

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664.1.055
Asea Reg. 885

The article briefly describes the collaboration between Asea and AB Landsverk in the development of completely automatic sugar centrifugals, with particular reference to the design, electrical equipment, working cycle and capacity.

In collaboration with AB Landsverk, Asea have developed a completely automatic sugar centrifugal which, during recent years has been installed in many factories both in Sweden and elsewhere. These centrifugals are now to be found in Belgium, France, Ireland, Mexico, the Congo, Mauritius and Australia, and orders have been received for supplying them to Denmark, South Africa and Iran.

The equipment which is supplied is, as far as possible, standardised into a single type, although, by means of minor changes, the standard unit can be made to fit in

with the different demands made on centrifuging for different qualities of sugar.

The present standard export design of the centrifugal itself consists of a basket with a diameter of 48" and a height of 30", which gives it a capacity of 440 litres. The basket is normally designed for a maximum speed of 1,300 r/m, but by increasing the thickness of the basket walls, the centrifugal can also be made for a maximum speed of 1,450 r/m, although then the capacity is reduced to 400 litres.

Various qualities of sugar require various centrifugal forces when treated, and, since the diameter is fixed, it must always be possible to run the centrifugal at different speeds if it is to fit in with all the demands made on it in practice. This is arranged by using a Leonard system with the driving motor directly connected to the shaft of the centrifugal.

The electrical driving equipment consists, in the main, of the following:

A separately excited d.c. motor (type LD 27) for a continuous rating of 48 kW at 1,440 r/m and 400 V. It can be overloaded to twice the rated torque without any dangerous sparking occurring. In order to provide better cooling and to prevent sugar dust entering the machine, fresh air is supplied to it from a separate fan.

A vertical converter set consisting of a d.c. generator (type LD 27), a constant-voltage exciter (type LD 11) and four-pole three-phase motor (type MKB 23) for connection to a supply network with a frequency of either 50 c/s or 60 c/s. The generator has three field windings, of which the one is self-excited while the other two are each excited by push-pull connected transducers (type YTCS 120). The three constant speeds for filling, centrifuging and ploughing are arranged by means of regulation at a constant motor voltage, while during acceleration and retardation, regulation is at a constant current.

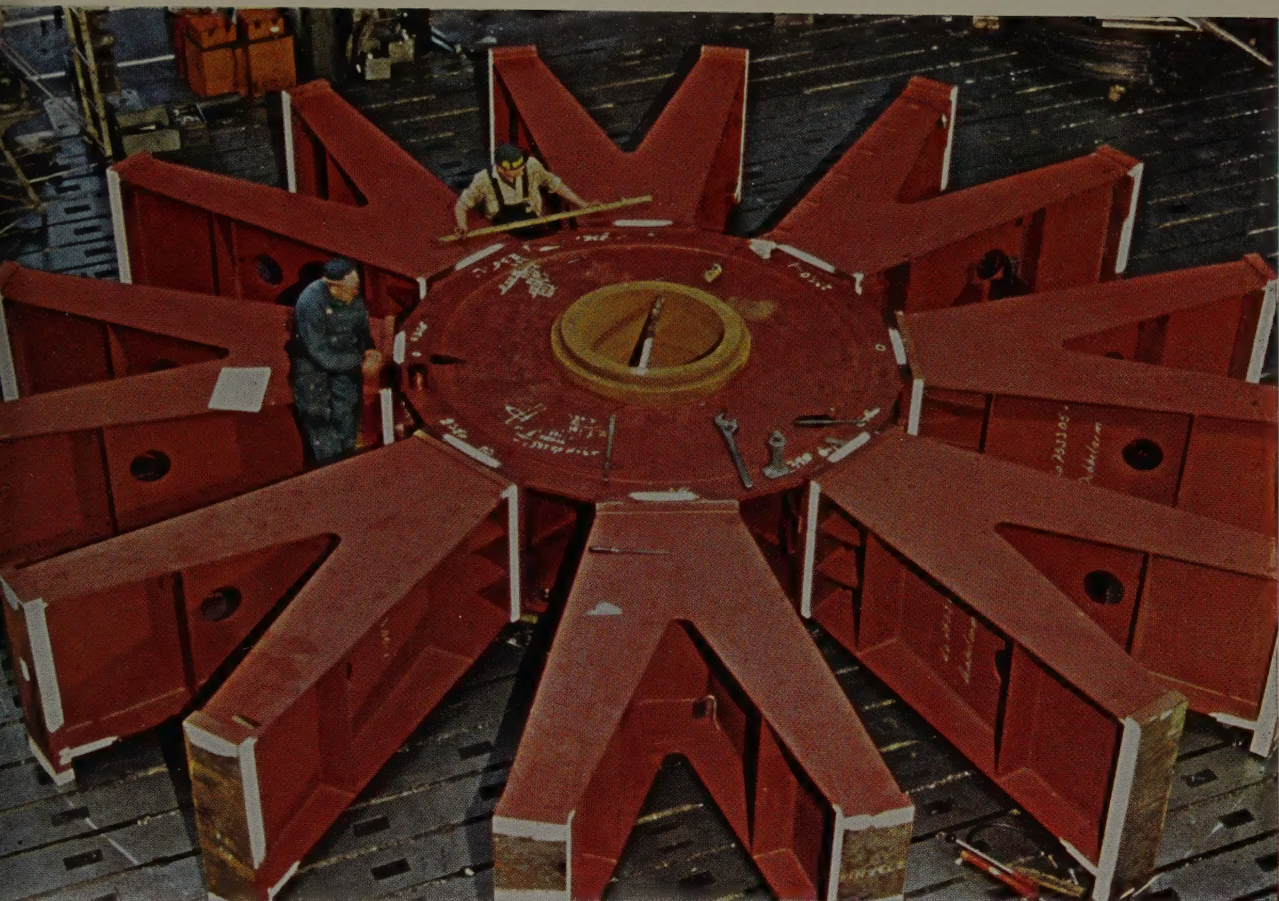
The working cycle for a sugar centrifugal is as follows:

1. Acceleration to charging speed.
2. Charging at a constant speed (approximately 200 r/m) takes place automatically in that a pneumatically operated valve is opened when the correct speed has been achieved and is closed when a preset quantity of massecuite has run down into the centrifugal.

3. Acceleration to centrifuging speed (1,000–1,450 r/m depending on the quality of the sugar). The rate of acceleration is kept virtually constant, and during this period the sugar is washed with water in accordance with a time programme.
4. Running at a constant speed for a set period of time.
5. Braking to ploughing speed, which takes place at a practically constant torque and with the regeneration of power to the supply network.
6. Ploughing of the finished sugar while the centrifugal rotates at a constant speed (approximately 50 r/m). The ploughing device consists of a motor-driven plough which both detaches the sugar from the side of the centrifugal and makes it run out through a hole at the bottom of the centrifugal. When the plough has returned to its original position, the new working cycle is automatically started.

The quantity of sugar which is produced by each centrifugal per unit of time depends very much on the quality of the sugar which is being worked. The maximum number of cycles per hour is determined by the centrifuging speed required. In the case of easily centrifuged massecuite, the top speed can be limited to 1,000 r/m, the centrifugal then completing 25 cycles per hour, while in the case of inferior qualities, the centrifugal must be run at 1,450 r/m and then will only complete 6 cycles per hour.

The illustration shows the centrifugal battery consisting of six units, set up in the Carlow Sugar Factory of the Irish Sugar Co. Ltd. Here, white sugar is made and the average production is 700 tons of sugar per 24 hours.



(F 555)

NEWS IN BRIEF

WELDED ROTOR SPIDER FOR STENSELE POWER-STATION
The illustration shows a welded rotor spider with a diameter of 8.5 m (28 ft)

and a weight of 38 tons. The spider forms part of a 55 MVA, 94 r/m generator in Stensele Power-station. The hub is designed to have the eight se-

parately manufactured double limbs bolted to it. Thus, the total number of limbs, and consequently of supporting points for the rotor rim, is 16. Asea Reg. 422

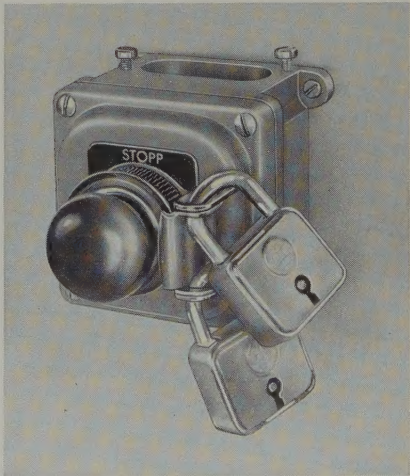
LOCKING DEVICE FOR PUSHBUTTONS

The pushbutton devices described in Sea Journal 31(1958):10, pp. 139-142 include some which can be locked with a key. However, it sometimes happens that more than one person needs to lock a pushbutton in the depressed position, thus blocking the button until all the locks have been removed. For this purpose, a locking device has been designed which is suitable for use with operating devices fitted with catch No.

5396 896 A and B (the catch housing is made of black plastic). However, it does not fit on to operating device 5396 638 A and B (catch housing of chromium-plated steel). The device can be locked by means of up to four padlocks with a shackle diameter of 4-6.5 mm (0.16-0.26 in.). The locking device is kept in stock and its number is 2167 697 A. Padlocks are not included.

Asea Reg. 5396

(53432)

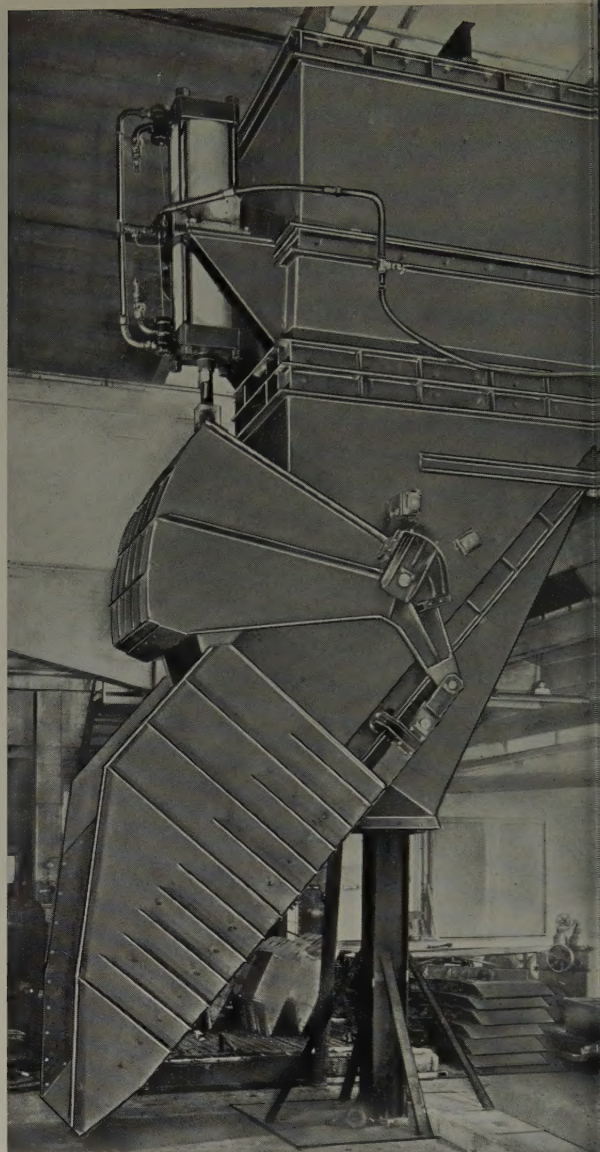


SKIPS AND MEASURING POCKETS FOR A NET LOAD OF 50 TONS

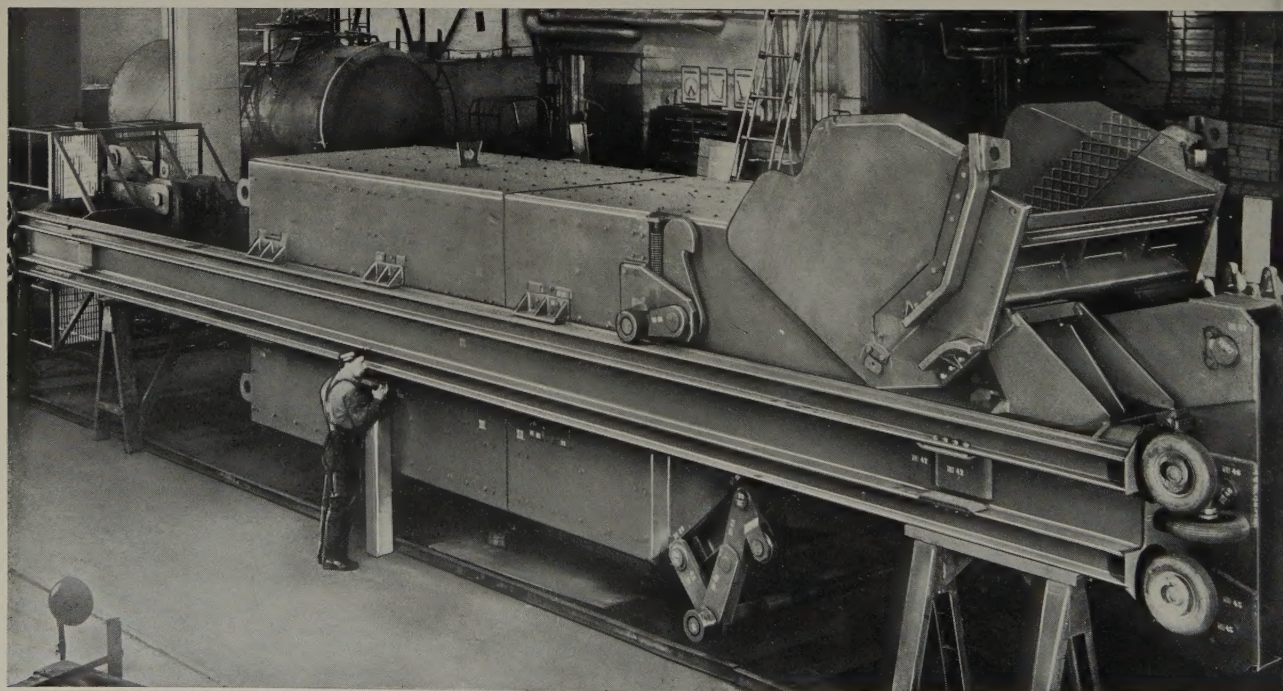
Asea have recently supplied mine equipment to the Soviet Union including two 4 m (13 ft), 8-rope, friction-drive hoists, see Asea Journal 33(1960):6, p. 100. The illustrations here show a skip and a measuring pocket, each for 50 tons of iron ore, volume 25 m³ (883 cu.ft), which is probably the largest net load hitherto handled by any mine hoist. The skip itself weighs about 40 tons and the measuring pocket about 30 tons.

Asea Reg. 632

(54981)



(538)



PRESSDUCTOR WEIGHING EQUIPMENT

Asea have supplied the Trollhätte Works AB Ferrolegeringar with pressductor weighing equipment for the weighing of the raw material used in the making of ferro-alloys.

The raw material is transported to three measuring hoppers arranged over an arc furnace. The contents of these hoppers serve as a material reserve. As the process continues, certain definite quantities of material are emptied into the furnace from these hoppers.

The pressductor weighing equipment is built up in the following way. Each measuring hopper rests on three transducer units of type TGPH (pressductor element built into a special pressductor housing). The weight of the material in the measuring hopper is indicated on dial instruments graduated in tons. The measuring instruments are placed on a control panel which also

Fig. 1. The control panel with the measuring instruments which show the total load in each measuring pocket. They can be read at a great distance. The control panel contains signal lamps which light for full-load and when the set weight charge load has been reached, as well as knobs for setting the weight of the material to be emptied from the hoppers. (5183)

contains the other regulating equipment required for the manufacturing process. The weighing equipment also includes relay equipment which gives a signal at full load when a hopper is filled to the top, and when a certain predetermined weight of material has been emptied out of the measuring hopper.

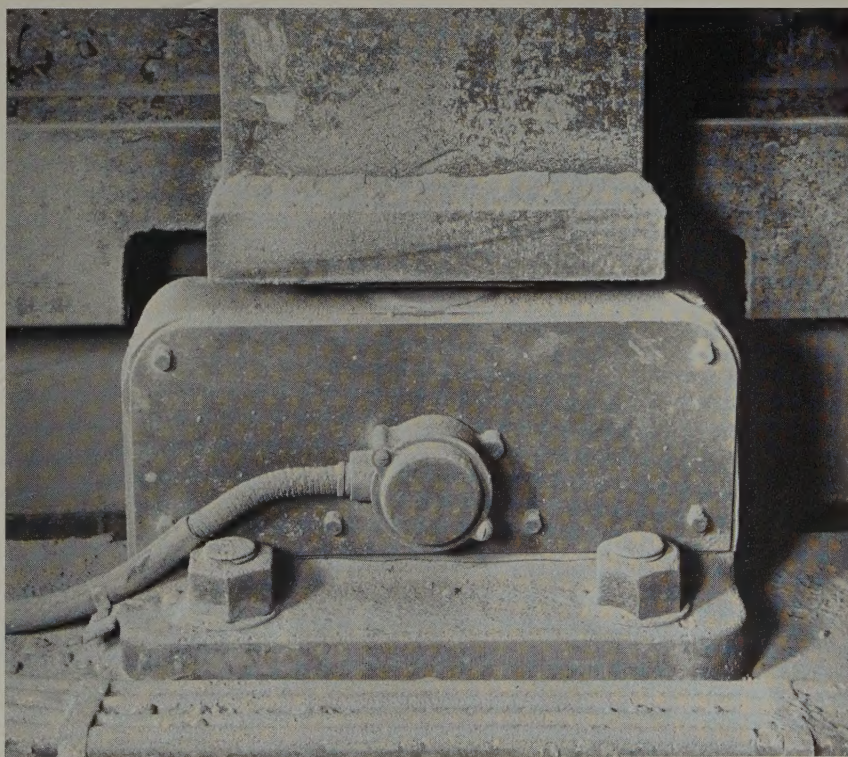
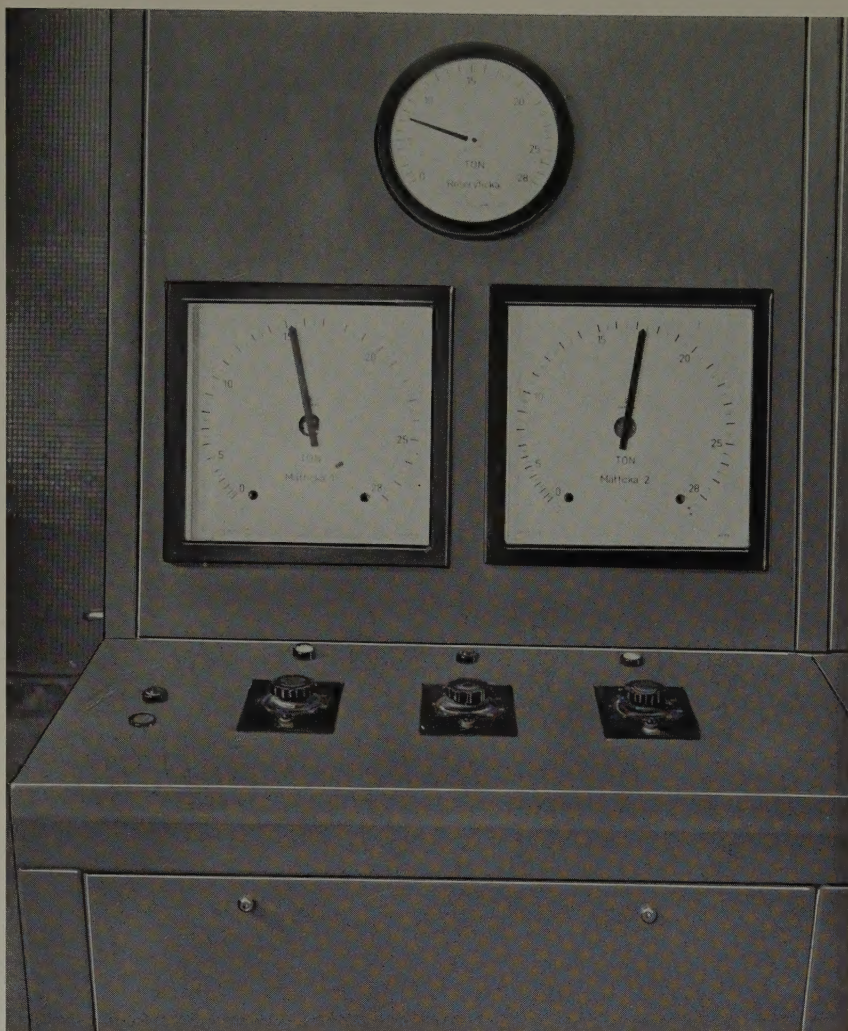
The desired full-load value in each measuring hopper can be set with the aid of a screwdriver. The amount which is to be emptied from a hopper can be set with the aid of a knob arranged over a dial graduated in tons.

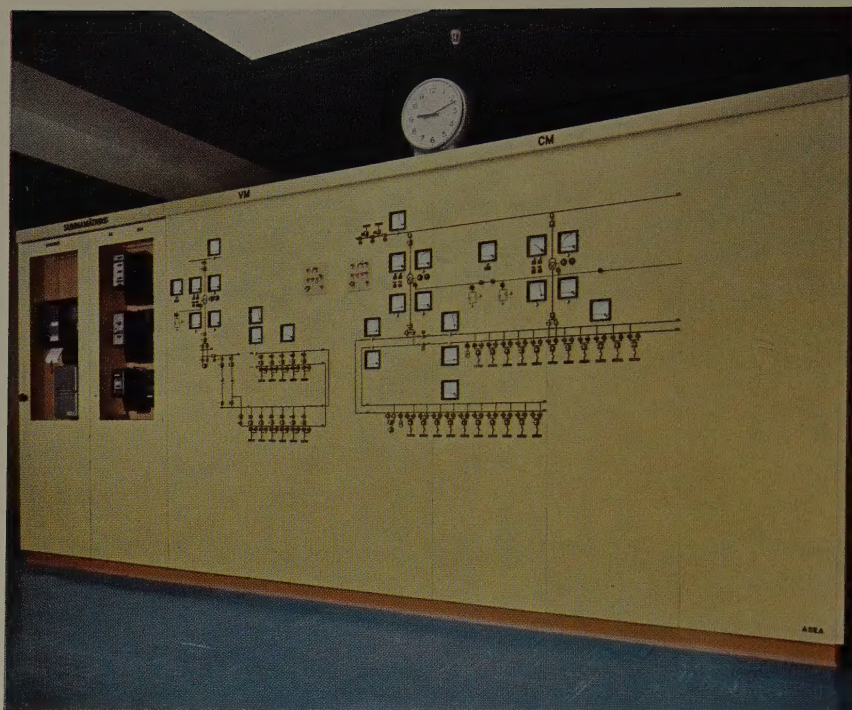
Because the pressductors have been placed in the immediate vicinity of the electrodes for the arc furnace, they are in an exposed position, but they have proved to be completely insensitive to the fields caused by the high electrode currents.

An accuracy of 2 per cent for the weighing system was stipulated, and it proved to be possible to keep well within this margin.

Asea Reg 5693

Fig. 2. One of the three pressductor housings on which a measuring hopper rests. (55184)





(F 572)

REMOTE-CONTROL PANEL IN THE CENTRAL CONTROL ROOM OF THE VÄSTERÅS MUNICIPAL ELECTRICITY AUTHORITY

The two 70/10 kV transformer and distribution stations in Västerås are supervised at the control board shown in the illustration with the aid of the Asea impulse code system. Only two wires are required between the control room and each transformer and distribution station for all operation, indication and selection of metering values. There are special pairs of wires for the transmission of various metering values. The operating switches are of type OMHC 1 and the selector switches and fault-indicating switches of type OMGA. Two metering panels can be seen on the extreme left of the board.

Asea Reg. 5756

The Asea Journal is published monthly review.

All correspondence should be added to the Editor, Publicity Department, Asea, Västerås, Sweden.

Articles or extracts from this Journal may be reprinted on condition the name - Asea Journal - is clearly stated.

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